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ABSTRACT

While much of microcomputer-based instruction (MCBI) is oriented to provide self-paced instruction to adjust for individual differences, there is some indication from cognitive theory that self-pacing may not be the best approach to improving learning. In addition, research in the area of cognitive imagery mediation has indicated that imagery learning strategies--based on imagery mediation--tend to significantly improve learning and later recall over the learner's own basic memory strategies. The present MCBI research--which instructed learners on the parts and operations of the human heart--evaluated two program-embedded learning strategies (the imagery cue strategy and the attention directing strategy) under three instructional conditions: externally paced (EP); externally paced plus imagery cue strategy; and externally paced plus attention directing strategy. Seventy-eight undergraduates in the College of Education at Ohio State University were given one of two sets of tests, visual or verbal, each to test such tasks as list learning, cued-recall task with visual or verbal orientation, simple concept learning, complex concept learning, and visual or verbal problem task with free recall. Data were analyzed using an analysis of variance procedure with repeated measures. Findings indicated that subjects without the learning strategies (the EP group) did not perform as well on visual as on verbal testing, and that the performance of the image cue and attention directing strategy groups was slightly improved on both verbal and visual testing. However, the EP group performed well on the verbal testing and slightly better than the strategy groups. (14 references) (CGD)

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The Effects of MCBI Program Embedded Cognitive Strategies For Performance On Verbal and Visual Testing

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Rationale & Related Literature

The present research study is an extension, and further refinement of a series of studies completed by the authors on micro-computer based instruction (MCBI) and cognition. Each of these research studies was designed to examine learning strategies and program embedded cognitive strategies to improve learning from MCBI. The first study examined a general learning strategy of program pacing, external-paced versus self-paced (Belland, et al 1985). While much of MCBI is oriented to provide self-paced instruction to adjust for individual differences, there is some indication from cognitive theory that self-paced may not be the best approach. For example, Wittrock (1979) noted that attention and motivation are key cognitive variables, indicating that as they are increased to optimal levels learning improves. Carrier also found that learners may not be the best judge of what to learn, when to learn, or how to learn new material (1984). The results of our first study supported these findings indicating that moderate levels of external pacing in the MCBI instructional program improves the amount learned and the competency level in using new material over self-paced MCBI.

Based upon these initial results, and research findings on other types of cognitive learning strategies (O'Neil 1978; O'Neil & Speilberger, 1978), two studies were desígned to examine the effects of cognitive strategies (Canelos, et al, 1986; Taylor, et al, 1987). If a pacing strategy could ímprove learning it is likely that a cognitive strategy, based upon fundamental cognitive processes, could provide additional learning benefits when learning from MCBI. Two areas of research were considered to determine the types of learning strategies to be evaluated. The first was the research on imagery mediation (Paivio, 1970), the second on meaningful learning theory involving attention directing strategies (Ausubel, 1968).

Cognitive imagery mediation research has a long history stemming from early work by Paivio (1970), Harowitz (1970), and others, to current work on imagery learning strategies (Dansereau, 1978; Kosslyn, 1975). Imagery learning strategies, based upon imagery mediation, tend to significantly improve learning and later recall over the learner's own basic memory strategies. Similarly, research on attention directing strategies has indicated that learning can be improved significantly if learners are provided strategies that improve attending behaviors thus helping them separate relevant from background information (Rothkopf, 1967). This research base led to the development of two program embedded learning strategies: the imagery cue strategy, and the attention directing strategy. These two strategies were evaluated in our next two MCBI studies, presented at the 1986 and 1987 AECT conferences.

The 1986 (Canelos, et al) and 1987 (Taylor, et al) studies evaluated learning from MCBI, with the added effects of the imagery cue strategy and an attention directing strategy. Both of these strategies were program embedded, indicating that the learner did not have to learn a strategy, but used the strategy while working through the MCBI program. These strategies are described in detail in Taylor, et al (1987). Results of this 1987 study on MCBI, and program embedded learning strategies indicated that the imagery cue strategy significantly improved learning, as did the attention directing strategy. However, the imagery cue strategy seemed to be more effective overall, particularly for spatial tasks. An additional finding was that an external-paced MCBI condition was better overall, when using program embedded learning strategies. While these first three studies allowed the refinement and development of MCBI pacing strategies, and program embedded learning strategies, the effects of testing needs to be further examined. The research on encoding specificity has indicated that there is a significant interaction between elements in instructional conditions, and testing (Tulving, 1979). For example, if visuals are a significant part of instruction, but do not occur during testing, performance can be adversely effected (Canelos, et al, 1985).

The present study will further examine the effectiveness of an imagery program embedded learning strategy, and an attention directing program embedded learning strategy, when learning from MCBI. However, this study will evaluate the relationship between MCBI program embedded strategy use and a visual testing method and verbal testing method. The following research hypothesis will be evaluated by the experimental design in Figure 1.

1) The program embedded cognitive strategies will allow learners to acquire more information from the MCBI program, than their own cognitive strategies.

2) The imagery cue program embedded learning strategy will be more effective overall for learning, than the attention directing strategy.

3) Verbal and visual testing will interact with learning strategy type, yielding an encoding specifity relationship.

4) Verbal and visual testing will interact with the level of testing difficulty.

Experimental Design

Figure 1 outlines the experimental design used in this study. The MCBI instructional programs will instruct learners on the parts and operations of the human heart. There are 57 instructional frames in each program, consisting of a visual, verbal labels, a brief verbal description, activity questions, then feedback. The basic design of each MCBI program will use an externally paced learning strategy. Two of the MCBI conditions will include program embedded learning strategies. One MCBI condition will have an imagery cue strategy. The second program embedded strategy will be the attention directing strategy.

1) Externally Paced Program

The first instructional condition was externally paced. The external pacing began after the instructional display was completed. After each instructional display was completed, the computer timed the student's interaction with the completed display at a pace of: (1) one second per each line of verbal instruction, plus one second; so for five lines, six seconds for reading were given, (b) seven seconds for cognitive processing were then given; (c) after reading time and cognitive processing time had elapsed, the instructional display was removed from the terminal screen.

To move forward, the learner pressed the return key to receive the activity question. The learner had as much time as required to respond. If the correct answer was entered, simple feedback was given and the student moved to the next instructional display. If the incorrect answer was typed in, simple feedback was given that indicated an incorrect answer. The learner was given the option of receiving elaborate feedback, which was the repeat of the instructional display containing the required answer. The elaborate feedback was optional; the learner could move to the next instructional display or take feedback. Feedback was a repeat of the instructional display and was timed the same way.

2) Externally Paced Plus Imagery Cue Strategy

The second instructional condition was identical to the first instructional condition, but with the addition of the program embedded strategy of an imagery cue strategy. The instructional content and content sequence were identical. The imagery cue strategy was presented in a program embedded format. The imagery cue strategy was a special screen display occurring every 5-7 instructional displays, prompting the learner to form a mental image of the heart parts seen thus far.

3) Externally Paced Plus Attention Directing Strategy

The third instructional condition was identical to the first instructional condition, in terms of content and content sequence, but with the addition of the attention directing strategy. The attention directing strategy was a program embedded strategy. The attention directing strategy was a five second time delay which occurred in each instructional display, between the presentation of spatial information and the accompanying verbal descriptive information. This tended to increase attention to the visual information in the instructional display.

The testing condition in the experimental design has five visual and verbal tests to evaluate performance on five intellectual skills: list learning, simple concept learning, complex concept learning, cued recall, and problem solving. All testing at one level is visual, involving either a visual cue, visual problem or spatial relationship. In the second level of the testing condition all tests are verbal using either multiple choice, or requiring a verbal description to complete a problem. The visual and verbal tests evaluate performance on the same intellectual skills, with test items on each test being isomorphic. Each of the five tests has 20 possible points. The only difference between the testing conditions is the use of either visual or verbal information in the way the test item is structured and presented to the learner.

Verbal Testing Conditions

1) List Learning Tasks

The list learning task was a simple memory task, requiring the learner to list the names of the parts of the heart and phase names.

2) Cued-Recall Task, Verbal Orientation

The cued-recall task consisted of 20 multiple choice items designed to test the learning of heart part locations. The test contained a line drawing of the heart with numbers and arrows indicating where each part was located. The 20 multiple choice verbal test items appeared under the numbered drawing and required the subject to identify specific parts and locations. While there was a spatial cue given, the structure of each test item was verbal multiple choice.

Sample Item

Arrow number eight (8) points to the

a. pericardium
b. endocardium
c. ectocardium
d. ectoderm
e. myocardium

3) Simple Concept Learning Task

In each item stem, the simple concept learning task items provided a description of a critical attribute about a heart part or operation. The learner selected the the heart part name or operation name from the available choices.

Sample Item

The _____ is the name given to the inside lining of the heart wall.

a. epicardium
b. endocardium
c. pericardium
d. myocardium
e. septum

4) Complex Concept Learning Task

The complex concept learning task items were complex in the sense that they involved "if-then" relationships of the parts of the heart during heart operation.

Sample Item

When blood is entering through the vena cavas it is also entering through the

a. mitral valve
b. pulmonary veins
c. pulmonary artery
d. aortic arch
e. aorta

5) Problem Task Verbal, Free-Recall

The problem task verbal free recall was considered the most difficult of the five verbal tasks. The learner had to prepare from memory a detailed written description of the heart, with the parts described in the correct location and function as to how they operate. The learner has to also describe blood flow through the heart pump system and the heart phases. There were 20 possible points on this task.

Visual Testing Conditions

1) List Learning Task

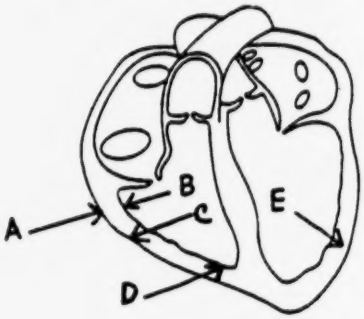
This task was the same for both types of testing, thus serving as a testing control for both groups, visual and verbal.

2) Cued-Recall Task, Visual Orientation

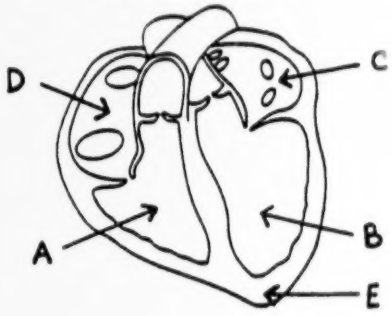
This task was visual in nature, but required similar knowledge as in its verbal task counterpart. The learner had to identify a heart part location, but in this case the test item was completely visual in structure.

Select the letter which correctly represents the part or function of the heart described in each question.

13. myocardium



14. left ventricle

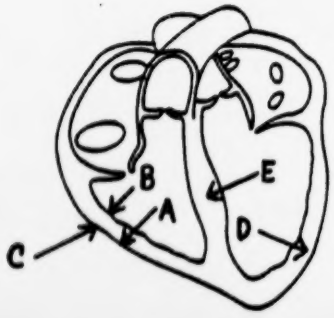


3) Simple Concept Learning Task

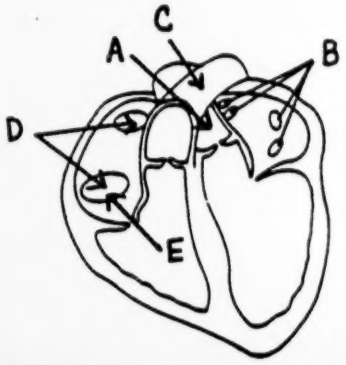
Again this task required similar knowledge as its verbal counterpart, but was visual in structure.

Select the answer you feel best identifies the part of the heart indicated by the numbered arrows and mark the corresponding letter on the provided answer sheet. All responses should be made in pencil.

32. The inside lining of the heart wall:



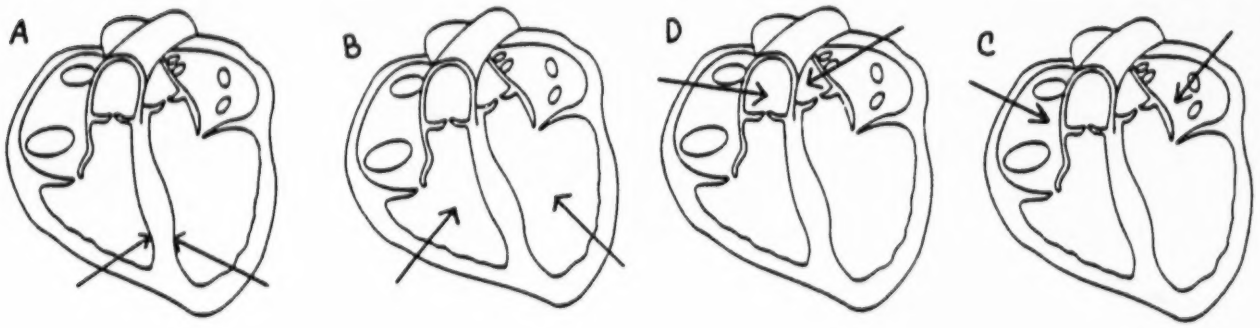
33. The part(s) of the heart through which deoxygenated blood enters:



4) Complex Concept Task

This task required the same knowledge of "if-then" relationships as its verbal counterpart, but was visual in structure.

44. The part of the heart in which the contraction impulse starts:



5) Problem Task Visual, Free Recall

The problem task visual free recall was considered the most difficult of the five tasks. The learner had to prepare from memory a line drawing of the heart with the parts indicated and in the correct location and labeled. Then the learner had to indicate blood flow through the heart pump system by drawing a series of dotted lines showing how the parts interact during heart operation, and then had to indicated the heart phases. Similar to the other learning tasks, there were 20 possible points on this task.

Procedures

There were 78 subjects participating in this study, having 13 subjects in each independent group. Subjects were undergraduates enrolled in College of Education at Ohio State University. Subjects were randomly assigned to one of the six independent groups in the study from a sign-up sheet.

On the day of the study subjects in each group were given a brief introduction about what they would be doing and then assigned to the computer center to work through the instructional programs. Subjects then went to a testing room, where they were given the five tests. Tests were given in an order so that cues were not given for other tests. Subjects were not aware that there were two basic types of testing, visual and verbal.

Data Analysis and Conclusions

Data collected have been analyzed using an analysis of variance procedure with repeated measures (ANOVR). Table 1 gives the summary results of the ANOVR. Table 2 provides the resulting main effect and simple effect means, with figure 2 providing a graph of the resulting significant interaction between MCBI, testing, and test difficulty.

This interaction indicated that subjects without the learning strategies, in the EP group did not perform as well on visual testing as on verbal testing. Additionally, the image cue strategy and attention directing strategy improved performance slightly on both visual and verbal testing. However, the EP no strategy group performed well on the verbal testing condition and slightly better than the strategy groups. There was a slight encoding specificity effect between visual and verbal testing with the EP no strategy group. Adding the program embedded strategies did slightly improve learning as was expected, but there are some cautions within the context of the present study.

It should be noted that this three way interaction is borderline statistically significant, at [.057]. This [.057] or [.06] value is not typically accepted as a statistically significant value. However, this study represents a preliminary study on visual and verbal testing with the three varied MCBI conditions. The small number of subjects in each independent cell of only 13, probably added to this result, and the other insignificant interactions. An additional problem with the experimental design is the use of an immediate testing condition. It is likely that the addition of a second within subjects variable of a one-week delayed testing condition would yield significant results on the main effects of MCBI type and visual versus verbal testing, along with significant interactions.

The hypotheses were not supported by these results probably because of the low number in each independent cell. Additionally, the one-week delay measure on testing could eliminate the effects of immediate memory and possibly yield significant results on both main effects and interactions. While the results were generally statistically insignificant the study should not be considered a complete loss. The experimenters were able to further refine the MCBI instructional programs, the visual testing condition, and found that program embedded strategies are beneficial. Additionally, the experimenters plan to repeat this study with an increased number of subjects in each indepdendent cell, and the addition of a one-week delayed testing variable. The next study will be a (3x2x5x2) ANOVR experimental design, with the same two between subject variables and two within subject variables, adding delayed testing.

While there is a good deal of pressure for researchers to produce significant results, it is necessary to conduct preliminary research to evaluate instructional and testing conditions, subject behavior, experimental designs, and experimental procedures. This situation is well known in the area of science, medicine, and engineering, where a line of inquiry may yield a series of studies with only minor refinements, eventually leading to significant results over the long run.

	External Paced MCBI (EP)		*EP MCBI & Image Cue Strategy (IC)*		*EP MCBI & Attention Cue Strategy (AC)*	
	Visual Testing	Verbal Testing	Visual Testing	Verbal Testing	Visual Testing	Verbal Testing
List Learning Task						
Cued Recall Task						
Simple Concept Task						
Complex Concept Task						
Problem Task						

FIGURE 1

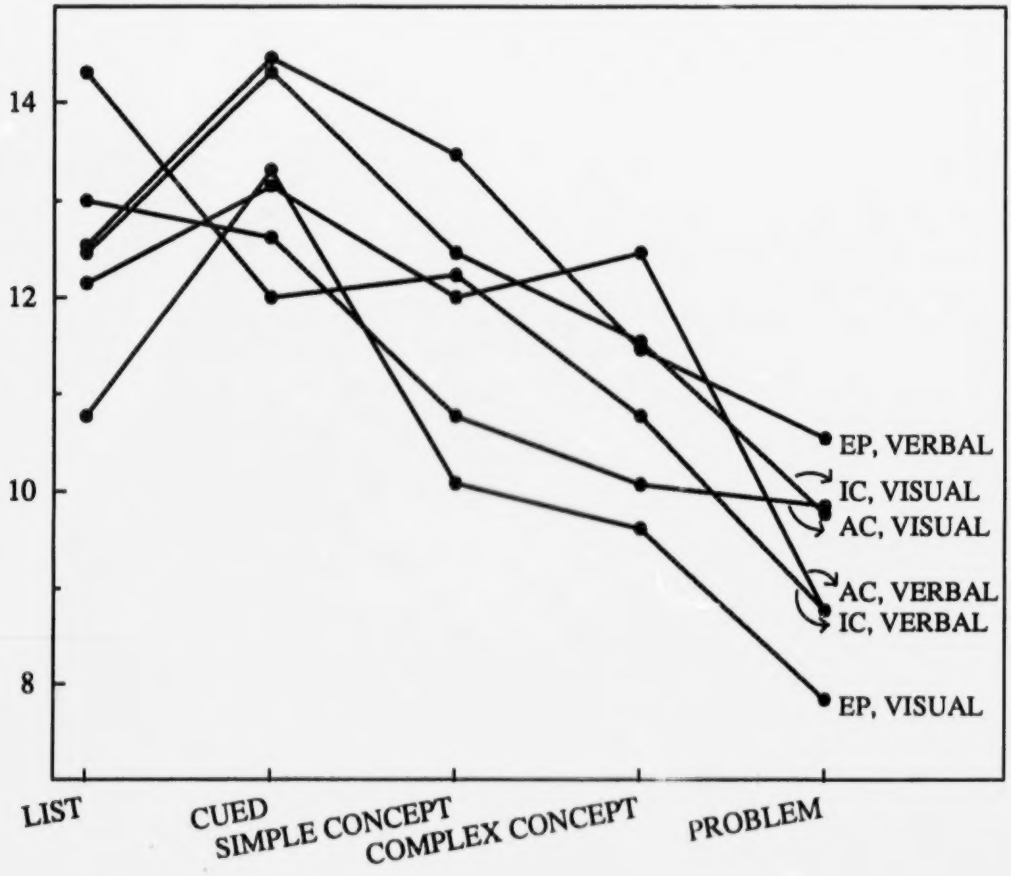

14
12
10
8
EP, VERBAL
IC, VISUAL
AC, VISUAL
AC, VERBAL
IC, VERBAL
EP, VISUAL
LIST
CUED
SIMPLE CONCEPT
COMPLEX CONCEPT
PROBLEM

FIGURE 2

ANOVR DATA

Source	***Mean Sq.***	***Df***	***f. Ratio***	***P***
Between				
MCBI (A)	7.699	2	.105	.90
Visual•Verbal (B)	48.831	1	.668	.42
A x B	59.223	2	.810	.45
Er.	73.101	72		
Within				
Test Level (J)	189.503	4	30.07	.002
A x J	7.246	8	1.15	.33
B x J	9.26	4	1.47	.21
A x B x J	12.095	8	1.92	.057
Er.	6.302	288		

TABLE I

	External Paced MCBI (EP)		*EP MCBI & Image Cue Strategy (IC)*		*EP MCBI & Attention Cue Strategy (AC)*		
	Visual Testing	Verbal Testing	Visual Testing	Verbal Testing	Visual Testing	Verbal Testing	
List Learning Task	10.77	12.54	12.46	14.31	13.0	12.15	12.54
Cued Recall Task	13.31	14.46	14.31	12.0	12.62	13.15	13.31
Simple Concept Task	10.08	13.46	12.46	12.23	10.77	12.0	11.83
Complex Concept Task	9.62	11.46	11.54	10.77	10.07	12.46	10.99
Problem Task	7.84	10.54	9.77	8.77	9.85	8.77	9.26
	10.32	12.49	12.11	11.62	11.26	11.71	
	11.41		11.86		11.48		

TABLE 2

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